CALIFORNIA DIVISION OF MINES AND GEOLOGY
FAULT EVALUATION REPORT FER-222

WHITTIER FAULT ZONE
Los Angeles and Orange Counties, California

by
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INTRODUCTION

The Whittier fault zone is the greater of two northern extensions of the active 250 km long Elsinore fault zone, the other being the Chino fault (Figure 1). This split occurs south of the Santa Ana River, in Riverside County, from which the Whittier fault zone extends northwest through Orange and Los Angeles Counties for at least 32 km along the southwest margin of the Puente Hills and perhaps further northwest, adjacent to the Montebello Hills. The Workman Hill fault branches off of the main fault zone in the northwesternmost Puente Hills. The principal sense of displacement on the Whittier fault zone is right-lateral strike slip. This fault zone was previously evaluated in Fault Evaluation Report 41 (Smith, 1977) and a supplement prepared by Hart (1979). An Alquist-Priolo Special Studies Zone was established in 1980 along portions of the fault zone in Orange County on the Yorba Linda and Prado Dam 7.5-minute quadrangles.

Recent work by Gath (in preparation and personal communication, 1990) as well as various consultant's reports (Leighton and Associates, 1981, 1987, and 1990) have provided new data and interpretations bearing on location, recency and recurrence of faulting on the La Habra and Yorba Linda quadrangles. Recent studies by Bullard and Lettis (1990b) suggest that the surface trace of the Whittier fault zone may extend northwest, across the Whittier Narrows on the El Monte quadrangle. This evaluation will address portions of the fault zone in Los Angeles and Orange Counties, to see if those portions not previously zoned meet the criteria of being sufficiently active and well-defined for inclusion within an Alquist-Priolo Special Studies Zone (Hart, 1988). The study area is covered by the El Monte, Whittier, and La Habra 7.5-minute quadrangles.

SUMMARY OF AVAILABLE DATA

Smith (1977) reviewed most of the then available literature and did not see sufficient data to warrant a Special Studies Zone. Hart (1979), upon review of more recent work by Hannan (see Hannan and others, 1979) concluded that portions of the fault zone in Orange County were sufficiently active and well-defined to be zoned under the Alquist-Priolo Special Studies Zone Act. Aerial photo interpretation was not attempted by either Smith (1977) or Hart (1979). Hart (1979) acknowledged that the fault zone had "not been evaluated in terms of recent fault rupture northwest of the Orange-Los Angeles County line."

The Whittier fault zone, at the northern end of the Peninsular Range geologic province, "is one of the most prominent structural features of the Los Angeles basin" (Yerkes, 1972). It is a northwest-trending zone of sub-parallel and branching, en echelon, steeply northeast-dipping faults. Its presence was suspected by Eldridge and Arnold (1907) who mentioned "the possibility of a fault of considerable magnitude, extending from the extreme west end of the [Puente] hills nearly or quite to Santa Ana River" (p.108). Among the first maps showing the fault was a geologic map by English (1926) who also noted numerous swales, saddles and deflected drainages along the fault which he attributed to erosion along the fault zone. Kundert (1952) described the Whittier fault as a high-angle reverse fault but he also cited as evidence for strike slip the apparent offset of Turnbull Canyon and La Mirada Creek "and the en-echelon orientation of the minor folds north of the Whittier fault".

The most complete published maps of the faults in the northwestern Puente Hills were at 1:12,000 by Daviess and Woodford (1949) and, of the Whittier and La Habra quadrangles only, at 1:24,000 by Yerkes (1972). Yerkes (1972) noted that the fault zone consisted of three main left-stepping en echelon faults. With regard to the stream deflections, Yerkes (1972) attributed this "at least in part, to strike-slip movement along the zone" and he commented that a "band of right-handed en echelon folds" were also likely due to right-lateral movement. The youngest geologic unit mapped by Yerkes to be displaced is probable late Pleistocene old alluvium, on the eastern half of the La Habra quadrangle. It is at the same locality where two attitudes from Miller and others (1977) are shown on Figure 2a. Other fault localities through younger materials were shown as concealed although this does not necessarily mean these materials are not faulted. Gath (in preparation, 1990) has made a fault map based on possible fault-related features along the entire fault zone as identified on aerial photos, but for the most part these features have not been field checked. These faults and the faults of Yerkes (1972) are shown on Figures 2a and 2b.

The fault zone is believed to have begun as an extensional feature in late Miocene time, probably with a right-lateral component, but is now dominantly a right-lateral oblique reverse fault (Maher, 1982; Leighton and Associates, 1987; Gath, undated, 1989?). In Orange County the zone of faulting is one to two thousand feet wide and commonly consists of two, but as many as three main strands (Morton and others, 1976; Tan and others, 1984). In Los Angeles County the fault zone may be as much as three thousand feet wide with one or two principal strands (Gath,in preparation; Yerkes, 1972). Yerkes (1972) puts basement relief at

2 to 4.7km, north side up, although this may be largely apparent since numerous stream channel offsets and other structural features suggest the possibility of significant amounts of right-lateral displacement (as much as 700m at Turnbull Canyon, 3300m at Tonner Canyon, and 1300m at Brea Canyon, Powder Canyon/La Mirada Creek and Carbon Canyon - Gath, undated, 1989?).

Recent trenching by Leighton and Associates (Eldon Gath, 1990, personal communication) adjacent to Tonner Canyon, less than two miles east of the La Habra quadrangle, has uncovered evidence of multiple late-Quaternary faulting events within a strike-slip related flower structure. Based on preliminary data, 12 to 15 thousand year old sediments have been displaced as much as 28 meters right-laterally (Eldon Gath, personal communication, 1991), yielding a slip rate as high as 2.3 mm/yr. Most of the submitted carbon samples, particularly younger samples, have not yet been dated but younger faulted materials are believed by Gath and Tom Rockwell to be Holocene. This trench site is within the limits of the present Special Studies Zone on the Yorba Linda quadrangle. Other trench localities in the Yorba Linda quadrangle which may have exposed Holocene faults were initially investigated by Nicoll (1970) and Tepel (1971) and have been discussed in detail by Lamar (1972), Tan and others (1984), Miller and others (1977) and Smith (1977). Further east Rockwell and others (1988) have inferred a long-term slip rate of 1.6 to 2.9 mm/yr right-laterally.

Work by Leighton and Associates (1990; also in Gath, 1989) along a new alignment for Fullerton Road has found two main strands of the fault zone. Ponding and tilting of sediments, dated at 11,820±120 ybp, has occurred behind the southern strand. Tilting of these sediments, dammed behind a shutter ridge, is described as increasing with depth and the deposits are said to include "liquefaction-type deformation". The northern strand, mapped continuously across the canyon, displaces sediments ponded behind a landslide. A radiocarbon age of 12,200 years was obtained from charcoal within these sediments. In the Fullerton Road area both Gath (in preparation, 1990) and Yerkes (1972) show two main strands of the fault in similar but not identical locations (Figure 2a).

Further west, in Arroyo San Miguel, Leighton and Associates (1987; Gath and others, 1988) excavated a series of trenches across the fault zone which established that small-scale drainages were offset, up to 10 feet right-laterally and from 2.5 to 8 feet vertically. Gath (undated, 1989?) comments that these drainages are cut into a terrace believed to be no older than 1500 ybp. A zone of sheared and brecciated material up to 25 feet wide was found within a 250 to 300 foot wide zone of faulting. A possible 6 to 8 foot paleo-scarp with an adjacent buried colluvial wedge was interpreted in one of their trenches. In another trench slickensides showed a dip as shallow as 12°W. A combination of topographic expression, the buried scarps, faulting of older alluvial deposits, and a faulted krotovina (estimated to be less than 1,000 years old) led them to conclude that the fault should be considered Holocene. Gath (undated, 1989?) comments that drainage swales at Arroyo San Miguel, which are cut into a terrace believed to be no older than 1500 ybp, are offset three to four meters right-laterally.

Near the western edge of the La Habra quadrangle, along the northern strand of the Whittier fault zone (probably not the Workman Hill fault as initially reported by Leighton and Associates, 1981 & 1987; Gath, undated, 1989?), Leighton and Associates (1981) described a 100' wide fault zone which affected the base of a colluvial deposit. Trench logs show intensely sheared bedrock with colluvium infilling numerous vertical fissures which appear to be related to the shearing. Radiocarbon dates of 12,090±390 and 17,240±860 ybp were obtained from the fissure filling (from bulk soil samples). Leighton and Associates (1981) considered the younger date to be more reliable, as a minimum age.

At the northwestern end of the Puente Hills, on the Whittier and El Monte quadrangles, Gath (in preparation, 1990) has identified several features in aerial photos which he attributes possibly to faulting. These correspond only locally with faults mapped by Yerkes (1972). (See Figures 2a and 2b).

At the northwest end of the fault zone, in the El Monte quadrangle, possible extensions of faulting beyond the Puente Hills were shown by the California Department of Water Resources (1966, map scale 1"=2 miles). These extensions are an unnamed northwest-trending fault along Alhambra Wash and the Workman Hill fault extension which parallels, in part, Rubio Wash. A more westerly-trending fault within the eastern Montebello Hills was mapped by Quarles (1941).

The fault along Alhambra Wash corresponds with the northeast margin of the Montebello Hills and may be the same as the steeply northeast-dipping fault which is shown to form the eastern boundary of the East Montebello Oil Field (California Division of Oil and Gas, 1961). Wright, (1987) concluded that the "Whittier fault almost certainly extends northwest beneath the Whittier Narrows to connect with the East Montebello fault". I have not been able to find a map showing the "East Montebello fault" by name but it probably refers to the northwest-trending subsurface fault shown by California Division of Oil and Gas (1961). Bullard and Lettis (1990b, map scale approximately 1"=6-7000') show a northwest-trending escarpment along the northeast margin of the Montebello Hills (see Figure 2b) as well as a subtler east-west trending escarpment along the southern margin of the hills west of this study area. With regard to the northwest-trending escarpment they state that it "cuts across interfluves and is not related to stream incision" and they postulate that it may be the surface expression of an extension of the Whittier fault. Bullard and Lettis (1990a) have suggested that the Montebello Hills have had a minimum Quaternary uplift of 80 to 150 meters.

The westerly-trending fault within the hills is noted by Quarles (1941) to cut Saugus formation (Pleistocene) but not displace terrace gravels. A small fault was exposed in a cut slope north of the Pomona Freeway and west of Whittier Narrows (Figure 2b). The fault, trending N75°W and dipping 60°-70°N, offset San Gabriel River gravels against older bedrock (Gath, undated, 1989? and personal communication, 1990). It does not align with any previously mapped faults.

The Workman Hill fault is described by Yerkes (1972). He states that the fault "probably predates the latest movement of the Whittier" fault. California Department of Water Resources (1966) describe the Workman Hill Fault Extension as offsetting Tertiary deposits at depth but they note that it "does not appear to affect the movement of ground water". The only reference in the literature to possible Holocene activity on the Workman Hill fault is unpublished work cited by Gath (undated, 1989?) and by Leighton and Associates (1981 & 1987). The locality described, however, near the west edge of the La Habra quadrangle, is here considered to be part of the Whittier fault zone based on continuity with other features.

SEISMICITY

Regional seismicity from 1973 to 1989 was shown by Hauksson (1990) and is reproduced here as Figure 3. There is a broad linear cluster of epicenters apparent adjacent to the Whittier fault, although, after isolating the strike-slip mechanisms, Hauksson (1990) felt these could not be correlated with any specific fault. Lamar (1972) and Lamar and Stewart (1973) recorded microseismicity from July 1971 to April 1972 in the vicinity of the Whittier fault to look for a correlation between subsurface pressure in the oil fields and earthquakes. They could find no evidence for a relationship between oil field activities and seismic activity. They did find, however, that 8 of 17 locatable hypocenters lay on the subsurface projection of the Whittier fault (based on a northerly dip of 60° to 70°. On the basis of the microearthquake activity associated with the fault zone they concluded that it must be active. Castle and Barrie (1988) found 6 additional hypocenters since 1973 which appear to fall on the subsurface projection of the fault. There is no reference in these studies to focal mechanisms for the hypocenters. Wright (1987) attributed the 1929 Whittier earthquake to the Whittier fault.

The epicenter of the October 1, 1987 Whittier Narrows earthquake is located on the El Monte quadrangle, near the fault zone, as is the largest aftershock, which had a strike-slip mechanism (see Figure 2b for epicenters). The main shock was not on the Whittier fault but was, instead, on a gently north dipping, east-west striking thrust fault (Hauksson and others, 1988). The main aftershock appeared to be on a steeply dipping, northwest striking plane. They speculated that this fault is a bounding structure for much of the deeper thrust mechanism foci associated with the main shock.

GEODETICS

A systematic or thorough search of geodetic data was not attempted but casual inquiry has found that the eastern 3000 feet of the Whittier Narrows Dam has experienced up to nearly one foot of relative uplift (minimum at the west end of this segment, maximum at the east end) over the course of several surveys of the dam since such surveys were first made in 1957; approximately 0.1 foot of this uplift occurred between April and December of 1987 (Chuck Orvis, U.S.Army Corps of Engineers, personal communication, December 1990) and may have been co-seismic with the October 1, 1987 Whittier Narrows earthquake. It is not possible to determine if this represents actual uplift of the eastern end of the dam or subsidence of the western part of the dam and its bedrock abutment. This zone of deformation lies across the trend of the Whittier fault zone between the Puente Hills and the Montebello Hills.

Another pair of survey lines showed deformation which occurred between January-February 1986 and October-November 1987 and which may be coseismic with the Whittier earthquake of October 1, 1987 (Lin and Stein, 1989). A north-south survey line, principally along San Gabriel and Rosemead Boulevards, showed that up to 50mm of uplift occurred in a broad warp across the Montebello Hills and the Whittier Narrows during the cosiesmic survey interval. Older survey data, however, showed that the southern half of the coseismic uplift area experienced 60mm of subsidence during the preceding decade (1975-1986). An east-west survey line showed a relatively uniform uplift with only a subtle bulge in the general vicinity of the Montebello Hills and the fault zone projection.

AERIAL PHOTO INTERPRETATION AND FIELD OBSERVATIONS

La Habra and Whittier quadrangles - (Figure 4a)

Significant right-lateral drainage offsets (roughly 4000 to 5000 feet) are visible on the topographic map at Brea Canyon (locality A), the first drainage west of Brea Canyon (locality C), at La Mirada Creek (locality O), and possibly at Arroyo San Miguel (locality T). Lesser offsets were observed at localities F, M, U, V and numerous minor drainages noted on the map. One major drainage offset east of Fullerton Road (locality J) corresponds with a fault mapped by Yerkes (1972). A large closed depression immediately to the west is the only other suggestion that this fault may be active, although this may be a result of a fault along its south margin or from lateral spreading.

As far as fine (small-scale) geomorphic features are concerned, the fault is not well-defined in the eastern part of the La Habra quadrangle, although a few small deflected drainages, linear drainages and tonal lineaments align with previously mapped faults to the east. I was able to corroborate many of the features observed by Gath (in preparation, 1990) as geomorphic features and I identified several more, but field checking revealed in some cases that no faulting was visible in relatively continuous exposures (see annotations on Figure 4a). Lithologic control of geomorphic features is a possible explanation for many of the features noted and hence an effort was made to look more specifically for consistent drainage offsets, beheaded drainages and other features more clearly indicative of fault displacement. Photo lineaments which do not coincide with mapped faults of Yerkes (1972) are not considered likely to be active structures unless they include clear tectonogeomorphic features.

Locality B is an alignment of two right-deflected drainages with other minor features. It is on the projection of mapped faults and other features to the east, on the La Habra quadrangle (see marginal annotation on Figure 4a). Locality D shows no consistent lateral drainage or ridge offsets and may be a result of differential weathering along an older minor fault. Locality E is an alignment of minor deflected drainages, lineaments and benches, however no faulting was visible in two separate oil pad cuts. Yerkes (1972) has mapped numerous attitudes adjacent to these lineaments which show no sign of distortion relative to each other, and two diabase units are mapped unbroken across the lineaments. Locality G coincides with the head of a mapped landslide and is probably a landslide scarp. Locality H is an alignment of consistently right-deflected small drainages, tonals and saddles that projects into a mapped fault. Landsliding, if present, may pre-date latest fault movement. Locality I consists of ambiguous features and does not correspond to any mapped faults, however it does parallel a syncline axis and may be influenced by bedding.

Locality K is a lineament adjacent to several very strong features including two closed depressions and it projects toward a major young splay of the Whittier fault identified in grading for the realignment of Fullerton Road (Leighton, 1980; Gath, 1989). Locality L is a lineament of very well-expressed troughs, benches and saddles which, although not associated with a mapped fault, are parallel to the main trace immediately to the south and are considered to be likely a result of recent faulting. Locality N coincides with the main mapped fault trace and is dominated by a prominent north-facing scarp. Locality P also coincides with a well-located trace of the fault and includes a noticeably offset ridge. The group of features at the general locality Q are subparallel to structure in relatively steep terrain and may be, in part, lateral spreading features associated with strong earthquakes.

West of Hacienda Boulevard, another distinct alignment of benches, saddles and linear drainages (locality R) is also probably controlled by bedding. In this case no drainages are deflected, further supporting an erosional rather than tectonic control. In contrast, one of the freshest-looking alignments of geomorphic features (locality S), less than 1000 feet to the south, does display right-deflected drainages along with sidehill benches, saddles and linear drainages. Trenching previously described (Leighton, 1981) near the western end of this lineament (see Figure 2a for location) showed that latest Quaternary faulting was associated with at least part of this alignment. Further west this lineament trails off into a linear canyon.

A second line of geomorphic features (note particularly stream offsets at localities T, U, and V), 2000 to 3000 feet further south, also align in large part with previously mapped faults (Yerkes, 1972) and lineaments identified by Gath (in preparation, 1990)(compare Figures 2a and 4a). In a recent oil well pad exposure adjacent to Arroyo Pescadero (near locality U) this fault appears to offset the soil or colluvial cover high on the ridge flank. A few other short features identified in aerial photos could locally be corroborated or denied based on oil well pad cut slopes (see annotations on Figure 4a). Geomorphic evidence for Holocene faulting is weak northwest of La Cañada Verde Creek, and it is difficult to say which of the several bedrock faults may still be active.

The few geomorphic features associated with the Workman Hill fault, such as saddles and linear drainages, lack any indication of tectonic origin, such as deflected drainages or scarps, and are probably fault-line features.

El Monte quadrangle - (Figure 4b)

On the El Monte 7.5-minute quadrangle, within the Puente Hills, there is only one notable lineament (locality W) which continues from the Whittier quadrangle. This lineament, however, projects directly toward a large bedrock exposure in an abandoned quarry which shows no indication of significant faulting. Further north (locality X) there is one tonal and vegetational lineament, along with the linear Rubio Canyon Wash, which might correspond to the Workman Hill fault extension, as previously mapped (compare Figures 2b and 4b). Another alignment (locality Y), within the flood control basin, of tonal and vegetational lineaments, small "knobs" in the 1926 topography, and a possible left-lateral deflection of an older channel of the Rio Hondo suggests that the fault, if it exists here, may step to the right. However, the extreme linearity of the southern portion of this feature, as well as the continuity of a possible buried channel across the lineament (visible in the 1927 aerial photos) make it suspect as perhaps a pipeline.

Another fault zone, along the northeast margin of the Montebello Hills (or Merced Hills in some older references), is indicated by a locally prominent scarp, vegetation lineaments, a break-in-slope, and a low linear ridge and swale which extend nearly four miles northwest from the Rio Hondo toward Alhambra (locality Z). These features are evident in the 1927 aerial photos as well as on the 6-minute topographic maps. The most prominent feature is a high (up to 60 feet) scarp which extends with diminishing height northwest from the Pomona Freeway to Delta Street (Figure 4b). A tonal or vegetation lineament was observed locally on aerial photos near the base of the scarp. Tonal features in the 1927 photos suggest a possible right step of the fault to the subtler lineament (including a roughly one meter high scarp) which extends northwestward from Walnut Grove Avenue to San Gabriel Boulevard. Weak tonals and a very gentle rise visible in the streets to the northwest may indicate that the fault merges into a gentle warp or fold which may continue to the San Bernardino Freeway near Jackson Avenue and continue for another few blocks as a tonal lineament. Additional broad linear ridges and swales are interpreted from the older topographic maps.

An additional linear drainage and line of topographic contrast runs northwesterly within the northeast flank of the Montebello Hills. This feature is apparently controlled by the contact between the older alluvium and the Tertiary bedrock units. The isolated fault mapped by Leighton and Associates (Gath, undated, 1989, and personal communication, 1990) north of the Pomona Freeway, west of Whittier Narrows, has no apparent lateral continuity nor surface expression and is probably not active. The undated "San Gabriel River gravels" which are reportedly faulted may relate to an older drainage.

Other features noted, based on the 1926 topographic map, are possible right-deflections of Rio Hondo and the San Gabriel River. There are no firm data or distinct lineaments, however, to support the idea that these are fault-related features.

DISCUSSION AND CONCLUSIONS

Based on the mapping of Yerkes (1972), Tan and others (1984), Rockwell and others (1988), and other work summarized in Morton and others (1976) and Miller and others (1977) the Whittier fault zone is a significant right-lateral fault with as much as 4,000 to 5,000 feet of Quaternary lateral displacement and 6,000 to 12,000 feet of basement relief (Yerkes 1972). Hart (1979) and Gath (undated, 1989?) have described or summarized evidence for Holocene displacement and Gath (1989) infers a minimum Holocene slip rate of 1.7 to 2.5 mm/yr near the southern end of the fault zone. The fault is well-defined by detailed geologic mapping (Durham and Yerkes, 1964; Yerkes, 1972; Tan and others, 1984).

In the area of concern to this evaluation (the La Habra, Whittier and El Monte quadrangles) there are numerous bedrock faults mapped, in the Whittier fault zone, by Daviess and Woodford (1949) and Yerkes (1972). Other faults have been locally mapped by various consultants. Aerial photo interpretation by Gath (in preparation, 1990) and for this evaluation reveals many geomorphic features which may be associated with faulting, either as fault-line features or as neotectonic offsets. In many instances geomorphic features coincide with previously mapped or currently identifiable faults. Where such features include consistently deflected drainages or prominent scarps, or where geologic investigation has shown Holocene or near-Holocene sediments to be faulted, it should be considered that the faults so defined, and reasonable projections of those faults, are active. In some cases aligned geomorphic features were found, based on local bedrock exposures, to not be associated with prominent faults. Lithologic and joint control of the topography provides an apparently valid explanation for many of the features observed.

Part of the Workman Hill fault is here considered to be more properly a part of the Whittier fault. East of Colima Road the northern trace of the Whittier fault coincides with what Yerkes (1972) considered to be the Workman Hill fault, but the trend of features interpreted from aerial photos continues westward and probably rejoins the southern trace of the Whittier fault in the vicinity of the large landslide at the western edge of the La Habra quadrangle.

Landsliding was also evaluated as a possible explanation for some of the geomorphic features observed. Landslides interpreted by Tan (1988; plotted on Figures 2a and 2b.) and additional landslides interpreted for this study (Figure 4a) were compared with mapped and interpreted faults. Only one arcuate pair of linear drainages with an intervening saddle, east of Fullerton Road, seems to correspond to a mapped landslide. A few lines of features cross mapped landslides and may indicate post-landslide fault displacement.

RECOMMENDATIONS

Two main traces of the Whittier fault zone on the La Habra quadrangle, as shown on Figure 5a, are well defined based on previous geologic mapping (Yerkes 1972; Leighton and Associates, 1981, 1987 and 1990) and geomorphic evidence. Some additional inferred faults are well-defined in aerial photographs (Gath, in preparation, 1990; independent photo analysis for this evaluation). These fault traces should be considered active for the purposes of the Alquist-Priolo Special Studies Zone Act based on the work of Gath (personal communication) near the western edge of the adjacent Yorba Linda quadrangle, findings of Leighton and Associates (1990) along Fullerton Road and near Colima Road (Leighton and Associates, 1981 and 1987), and the nature of the geomorphic expression, particularly along the more northerly trace. In general the Whittier fault zone is poorly defined geomorphically on the Whittier quadrangle and it is not possible, based on available information, to differentiate which traces may be active.

On the El Monte quadrangle the Whittier fault zone shows no surface expression in the northwestern part of the Puente Hills, but is clearly indicated northwest of Whittier Narrows by a marked escarpment in late Quaternary deposits along the northeast margin of the Montebello Hills (Bullard and Lettis, 1990b) as well as other lineaments and features identified in aerial photos and older topographic surveys. Earthquake epicenters with strike-slip mechanisms are probably associated with the northwest extension of the fault zone.

I recommend zoning those portions of the Whittier fault zone indicated on Figures 5a and 5b. The traces on Figure 5a are based principally on the mapping of Yerkes (1972) but are modified locally based on aerial photo interpretation and local consultants' data as referenced on the map.

The Workman Hill fault, although expressed locally in the topography, does not show any evidence of Holocene activity and is not recommended for zoning. The limited expression, principally tonal and vegetation lineaments and linear drainages, are probably fault-line features unrelated to tectonic activity.

The Workman Hill fault "extension" has only vague and ambiguous expression and should not be zoned. The sharper lineament which cuts the Rosemead Boulevard/Pomona Freeway interchange likewise is ambiguous and should not be zoned at this time.

Reviewed & recommendations approved. Earl W. Hart CEG 935 2/27/91

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AERIAL PHOTOGRAPHS USED

Fairchild Aerial Surveys
flight 113 1927 b/w 7x9 1:18,000
463 to 470
495 to 503
548 to 557
589 to 596
603 to 608
642 to 646
685 to 687
732 to 734
777 to 779
817 to 820
855 to 857

Fairchild Aerial Surveys
flight C-300 1928 b/w 7x9 1:18,000
K399 to K402
L23 to L27
L50 to L52
L77 to L80
L104 to L106
L135 to L137
L163 to L165

Fairchild Aerial Surveys
flight 5925 b/w 9x9 1:24,000
10/14/39 frames 126 to 128

U.S.Department of Agriculture b/w 9x9 1:20,000

11/10/52	AXJ- 5K-10	to -12
10/19/53	AXJ-13K-152	to -155, -181 to -183
8/31/54	AXJ-19K-40	to -42, -56 to -59
12/26/52	AXK- 5K-74	to -76
5/30/53	AXK- 6K-25	to -27
6/ 4/53	AXK- 6K-88	to -90

U.S.Department of Agriculture b/w 7x9 1:20,000
(enlarged to 1:12,000)

5/22/38	AXJ	27-7	to 27-9
5/23/38	AXJ/AXK	27-77	to 27-83
5/30/38	AXK/AXL	39-109	to 39-115
5/30/38	AXJ/AXK	40-1	to 40-7

U.S.G.S.

Flight GS-VEZT 11/01/80 b/w 9x9 1:24,000
Roll 1, frames 2-5, 17-19, 25-28, 39-41, 50-52, 88-90, 126-128, 141-144
11/21/80
Roll 3, frames 7-11, 42-44
3-59 to 3-60

Flight GS-VEZS 10/20/80 b/w 9x9 1:24,000
Roll 2, frames 33-36

TOPOGRAPHIC MAPS USED

U.S.G.S., Los Angeles County, 6-minute series 1:24,000
Alhambra, edition of 1926
El Monte, edition of 1948
El Monte, edition of 1926 (U.S.Army Map service reprint of 1942 at 1:20,000)
La Habra, edition of 1927
Whittier, edition of 1925

U.S.G.S., 7.5-minute series 1:24,000
El Monte, 1966, photorevised 1981
La Habra, 1964, photorevised 1981
Whittier, 1965, photorevised 1981

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California Department of Water Resources, 1966, Planned utilization of ground water basins; San Gabriel Valley, Appendix A: Geohydrology: California Department of Water Resources Bulletin 104-2, [Areal Geology-Plate 9A, 1"=2 miles].

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